

A NEW SPECIES OF RUPPIA IN HIGH SALINITY IN
WESTERN AUSTRALIAJ. S. DAVIS¹ AND P. B. TOMLINSON²

THE SYSTEMATIC POSITION of *Ruppia*, whether isolated from or closely associated with the larger genus *Potamogeton*, has occasioned some disagreement in the taxonomic literature. Hutchinson (1934, 1959) represents a minority view by including *Ruppia* in a family (Ruppiaceae) separate from *Potamogeton*, whereas other authors include the two genera in the same family. Although there are obvious differences between *Potamogeton* and *Ruppia*, Hutchinson's view stresses them at the expense of their considerable similarities. However, this attitude, in turn, should be viewed against the modern tendency to dismember the originally large assemblage of the Potamogetonaceae (*sensu lato*) and erect smaller families like Cymodoceaceae, Posidoniaceae, Zannichelliaceae, Zosteraceae. This approach is reflected in the system of Takhtajan (1966) as well as that of Hutchinson. The question might therefore be asked about *Ruppia* — does it show the same degree of difference from *Potamogeton* as do these families from each other, sufficient to warrant its segregation in the Hutchinsonian manner? In view of the many evident similarities between *Potamogeton* and *Ruppia*, in terms of vegetative morphology and anatomy, but particularly of floral morphology (Uhl, 1947), the question would seem still to be an open one. The discovery of a new species of *Ruppia* (described here) with certain hitherto unrecorded morphological peculiarities which recall *Potamogeton* is of interest. The distinctive diagnostic features may be related, in part, to the unusual environment in which the plants were growing; so the habitat, which has been studied by the senior author, also deserves description.

The number of taxa within *Ruppia* remains uncertain chiefly because the plant is polymorphic and species are distinguished by relatively slight morphological differences of the reproductive parts, but especially of the fruits (e.g. Mason, 1967). Setchell (1924, 1946) laid emphasis on the ecotypic variation within *Ruppia*, and he considered that most diagnostic criteria which had been used to separate taxa were subject to this variation. The only careful cytotaxonomic survey has been carried out by Reese (1962) on the European forms, and his approach is very illuminating.

¹ J.S.D. The opportunity to study the flora and fauna of the solar salt system of J. O. Clough and Son Pty. Ltd. of Perth, Western Australia, is gratefully acknowledged.

² P.B.T. Work on the anatomy and morphology of monocotyledons was supported by National Science Foundation grants GB-5762x and GB-31844-x. A general account of the morphology and anatomy of *Ruppia* which will be published in a forthcoming volume (vol. VII, the Aquatic Monocotyledons. Alismatales-Najadales of "Anatomy of the Monocotyledons," ed. C. R. Metcalfe) is subsequently referred to as "Tomlinson, unpublished."

MATERIAL

Specimens were collected by one of us (J.S.D.) during the last week of August and the first weeks of September, 1970, in two ponds and several ditches on the property of Shark Bay Gypsum Company of Western Australia. The locality is at Useless Inlet on the Heirisson Prong of the Carrang Peninsula in the southern part of Shark Bay. The ponds (which are identified by letters) and the ditches are the intermediate part of the solar salt system in which sea water is evaporated to produce sodium chloride. In addition to herbarium specimens (deposited in the Herbarium of the University of Florida, FLAS), material was fixed in 70% alcohol. This provided opportunity for morphological study (by P.B.T.). Habit drawings and detailed illustrations were also prepared from this pickled material.

OBSERVATIONS

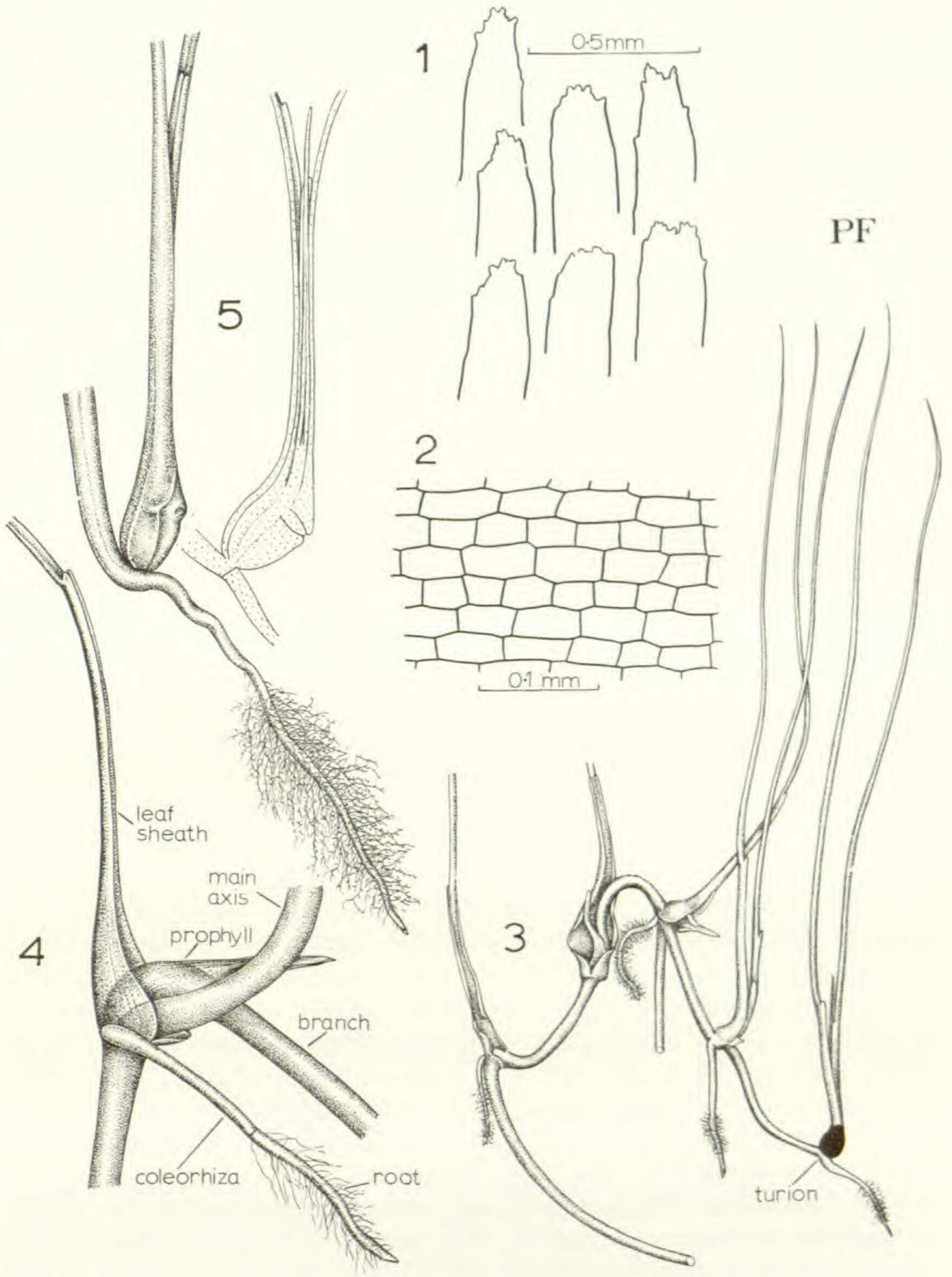
Ecology. The time of collection was the early spring of this part of Australia. At this time the plants were flowering and shedding their anthers, these often becoming concentrated by the wind into yellow films up to several square feet in area in certain parts of the pond. Many plants, however, were producing fruits. Plants were abundant in Pond V and Pond W of the solar system and in the ditches parallel to these two ponds. The plants grew in dense tufts covering up to several square feet of the bottom. Plants in various stages of maturity and varying in size were evident everywhere, from seedlings (FIGURES 1-7) to flowering specimens (FIGURES 8-10).

All the mature plants were dark green, firmly rooted, and with their rhizomes completely buried; they looked healthy and appeared to be growing vigorously.

The water in which the plants grew was clear, with depths varying from about three inches to two feet; the temperature range was 68-70° F. Of chief interest was the salinity of the water at the *Ruppia* locations, which ranged from 92 to 132 parts per thousand of dissolved salts, as determined with a corrected Bäume hydrometer. This represents a range of salinity from 2.6 to nearly 4 times that of ocean sea-water.

Ruppia was absent from the large pond which is used to supply water to Pond V (of about 1,000 acres), even though the salinity in both these bodies of water was the same. During windy days, however, wave action on the larger pond was noticeably severe. The ponds receiving the water of Pond W contained no *Ruppia*. These ponds are small and shallow but salinities were over 200 parts per thousand.

Ruppia tuberosa Davis & Tomlinson, sp. nov. Foliis brevibus (usque ad 8 cm. longibus), angustis (usque ad 0.3 mm. latis); apice folii rotundato irregulariter. Carpella plurima (usque ad 12); fructi sessili (deficientes podogynam), crista prominenti laterali dentato, non rostrata.



FIGURES 1-5. *Ruppia tuberosa*: 1, outline of leaf apex, $\times 45$; 2, epidermal cells of leaf, $\times 150$; 3, monopodial branching system of proximal parts, $\times 2$; 4, detail of node on proximal parts, $\times 6$; 5, detail of turion, $\times 6$, in diagrammatic longitudinal section to right.

Surculi evolventes tubera tumida aut turiones conspicuos (usque ad 1.5 mm. diametro). TYPE: In hypersaline water (up to about 4 times the salinity of sea-water) in salt ponds, Useless Inlet, Shark Bay, Western Australia. *J. S. Davis s.n.* 4 Sept. 1970 (FLAS).

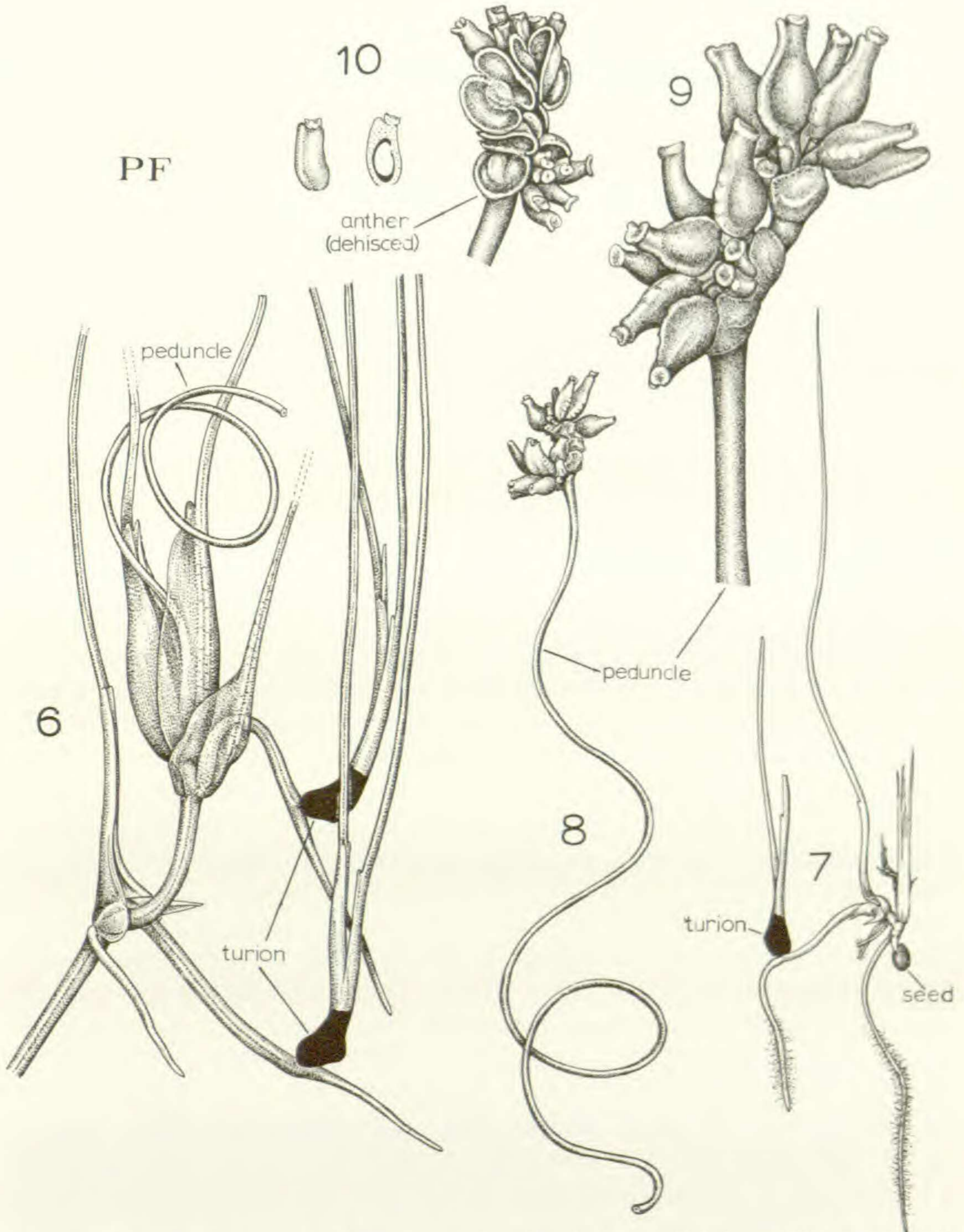
Leaves to 8 cm. long, narrow; blade scarcely 0.3 mm. wide at a level halfway between its base and apex; apex (FIGURE 1) irregularly rounded with 1- to few-celled apical teeth, rarely bidentate; epidermal cells of the order of 60 μm long, 30 μm wide (FIGURE 2). Shoots ending in conspicuous starch-filled swollen tubers (turions) up to 1.5 mm. wide. Peduncle long, exceeding the leaves, sometimes helically coiled; carpels (female flowers) numerous, always more than 4 (up to 12), with a prominent lateral crest. Fruits sessile (lacking a podogyne), more or less regularly flask-shaped and without a pronounced apical beak, but with a prominent transversely ridged lateral crest when young.

This species differs from all previously described forms of *Ruppia* in its sessile fruits and turions. The leaves are exceptionally narrow and short for the genus. It resembles *R. polycarpa* Mason in its numerous carpels, narrow leaves, and blunt leaf apex, but the shape of the fruit seems to be very different. We have no chromosome counts, which in view of the work of Reese (1962) and Mason (1967) would be very desirable.

Morphological details. In its general morphology the Australian *Ruppia* resembles other *Ruppia* species in so far as they have been described (e.g. Gamarro, 1968; Graves, 1908; Irmisch, 1858; Tomlinson, unpublished). For our present purposes, comparative material has been provided by a population of *Ruppia* (tentatively identified as *R. maritima*) in the brackish-water lakes towards the seaward side of Fairchild Tropical Garden and by a population in high salinities in the Bahamas. The transition from monopodial growth in the proximal vegetative parts (FIGURES 3, 4) to sympodial growth in the distal reproductive parts (FIGURE 6), which is characteristic of *Ruppia*, is clearly shown. In the former phase each foliage leaf subtends an axillary bud and each node has one adventitious root (sometimes more). In other *Ruppia* species roots are infrequent or lacking distally, but in *R. tuberosa* they seem present at all nodes, even distal ones (FIGURE 6). Modified leaves with inflated sheaths are associated with each terminal inflorescence (FIGURE 6). Renewal shoots (one or more) arise singly either in the axils of these modified distal leaves, or in those of the lower ones.

In the Australian *Ruppia* the extremity of each shoot tends to be abruptly recurved (FIGURES 3, 6, and 7). The terminal bud itself is then usually represented by a swollen structure which is conspicuously white or yellowish. These tuberous organs, which we may refer to as "turions" are displaced into a pseudolateral position so that the adventitious root appears to be a direct continuation of the main axis (FIGURE 5). Dissection and free-hand sectioning show that the turion consists largely of a single short internode in which the cortical parenchyma is distended and

filled with starch. There is a single unextended root primordium at the upper node, visible externally, and in section obviously continuous with the stele (FIGURE 5). The turion is enveloped by the leaf inserted at its proximal end; the insertion of the leaf at its distal end is obscure,



FIGURES 6-10. *Ruppia tuberosa*: 6, detail of sympodial branching of distal parts in association with terminal peduncle, $\times 3$; 7, seedling, $\times 2$, with initiation of turion in post-seedling phase; 8, peduncle with young fruits, $\times 4$; 9, detail of fruiting head, $\times 6$; 10, old inflorescence with dehiscid anthers and female flowers, $\times 6$, inset to the left, detail of female flower in side view and longitudinal section.

largely because the ground tissue at the base of this leaf is also somewhat enlarged and starch-filled. A number of unexpanded leaf primordia are present in the turion. Turions occur throughout the plant and have been seen on seedlings which had produced very few leaves (FIGURE 7). They also had developed on renewal branches from nodes at or close to terminal inflorescences (FIGURE 6). Turions themselves remain unbranched, although there is a bud in the axil of their lowest leaf. Turions may be contrasted with normal shoots in which developing internodes are not swollen and the youngest extended root is obviously lateral (FIGURE 4).

In the material available the reproductive parts all represent relatively late flowering stages. Peduncles are long and often spirally twisted (FIGURE 8). The youngest stages were flowers which still retained dehiscent thecae together with mature carpels (FIGURE 10) or fruits (FIGURE 9). These fruits were in groups of up to 12. Large numbers of ripe fruits were developed on some inflorescences. Individual fruits lack the podogyne which is otherwise normal in *Ruppia*. They are sessile and each has a pronounced dorsal and transversely ridged crest (FIGURE 9).

DISCUSSION

This species is unusual in several respects. Most obvious are the turions, which are modified shoots which serve for storage and possibly propagation, although we had no means of verifying this. Such organs seem never to have been described for *Ruppia*, and several authors (e.g. Graves, 1908; Kirchner et al., 1908) specifically mention the absence from *Ruppia* of any winter bud or other organ comparable to the structures commonly developed in several species of *Potamogeton* (e.g. Irmisch, 1858; Hagström, 1911). Setchell (1946) mentions the lack of storage starch in *Ruppia*. The similarity between the types of "resting" structure in *Ruppia* and *Potamogeton* is not close, however, since those of *Ruppia* include only one internode, whereas those of *Potamogeton* usually include several internodes. Winter buds or turions otherwise appear not to develop in those families of aquatic monocotyledons closely allied to the Potamogetonaceae (sensu stricto). The only possible confusion could be with the "tubercles" developed in *Ruppia* (and other genera), which are known to be a pathological response (e.g. Hisinger, 1887). There is no evidence that the modified shoots developed by the Australian *Ruppia* are pathological. It seems unlikely that these organs have been induced by the high salinity of their environment, since *Ruppia* is known to endure a wide range of salinities (Setchell, 1924). For example, our collection of *Ruppia* from Long Island, Bahamas, came from salt ponds with a salinity approximately twice that of sea-water. The only recorded morphological effect of salinity is on fruit size (Mayer, 1971). Tolerance of *Ruppia* to high salt concentration may be subject to genetic variation. Graves (1908) showed that leaf and root cells of *Ruppia maritima* were plasmolyzed at salt concentrations little higher than that of sea-water, suggesting

to him that *Ruppia* might not endure high salt concentrations; on the other hand, *Ruppia* evidently exists in high salinities.

The presence of turion-like organs and sessile fruits in this species, both features of the genus *Potamogeton*, can be cited as evidence for a relationship between *Potamogeton* and *Ruppia* which is best expressed by including them in the same family.

SUMMARY

A new species, *Ruppia tuberosa*, is described from Western Australia occupying hypersaline habitats (with up to 4 times the salt concentration of sea-water). A morphological peculiarity is the development of swollen shoots, rich in starch, at the end of almost all axes. These recall the turions or winter-buds of *Potamogeton*. Organs of this kind have not been recorded for *Ruppia* before and are used as evidence to demonstrate the close relationship between these two genera. Additional peculiarities include the individually sessile fruits, each of which has a prominent dorsal ridge.

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